Faculty of Resource Science and Technology

WATER QUALITY STUDY OF WATER INTAKE IN ASAJAYA WATER TREATMENT PLANT

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This project is submitted in partial fulfillment of the requirements of the degree for Bachelor of Science with Honours

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DECLARATION

I hereby declare that no portion of the work referred to in this dissertation has been submitted in support of an application for another degree or qualification to this university or any other institution of higher learning.

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Table of Contents **Page**

List of Abbreviations

BOD_5	Five days biochemical oxygen demand
COD	Chemical oxygen demand
DO	Dissolved oxygen
DOE	Department of Environment
INWQS	Interim National Water Quality Standards
MOH	Ministry of Health
ORP	Oxidation-reduction potential
TDS	Total dissolved solids
TSS	Total suspended solids
WQI	Water quality index

List of Tables

List of figures

		Page
Figure 1	Study area of intake site in Sungai Asajaya.	10
Figure 2	Temperature, pH and DO mean values in Aug – Dec 08' and Jan 09' at 3 sites.	20
Figure 3	Turbidity and salinity mean values in Aug – Dec 08' and Jan 09' at 3 sites.	22
Figure 4	ORP mean values in Aug – Dec 08' and Jan 09' at 3 sites.	23
Figure 5	Conductivity and TDS mean values in Aug – Dec 08' and Jan 09' at 3 sites.	25
Figure 6	Nitrate, ammonia-N and orthophosphate mean values in Aug – Dec 08' and Jan 09' at 3 sites.	28
Figure 7	COD and TSS mean values in Aug - Dec 08' & Jan 09' at 3 sites.	30
Figure 8	BOD_5 and chlorophyll-*a* mean values in Aug - Dec 08' & Jan 09' at 3 sites.	32

List of appendices

Water Quality Study of Water Intake in Asajaya Water Treatment Plant

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ABSTRACT

This study was conducted to determine the water quality of Asajaya water intake in Kota Samarahan through physico-chemical parameters. Fifteen water quality parameters were measured which includes temperature, pH, DO, salinity, turbidity, conductivity, TDS, ORP, nitrate, ammonia-N, orthophosphate, COD, TSS, chlorophyll-*a* and BOD_5. Measurement of physico-chemical parameters were carried out from August 08' - January 09' at 3 different sites. ANOVA analysis shows that there were no significant differences in water quality parameters among the 3 sites of sampling except for orthophosphate, BOD_5, TSS, DO, temperature and nitrates. However, there were significantly differences in water quality parameters among the six months. The mean physico-chemical parameters for temperature (25.68 ^{0}C), pH (5.01), DO (3.10 mg/L), salinity (0.01 PSU), turbidity (66.24 NTU), conductivity (4.62 mS m^{-1}), TDS (0.04 g/L), ORP (231.04 mV), nitrate (0.02 mg/L), ammonia-N (2.00 mg/L), orthophosphate (0.48 mg/L), COD (72.84 mg/L), chlorophyll-*a* (1.23μg/L), TSS (1.54 mg/L), and BOD_5 (1.19 mg/L). The average of WQI calculated in Asajaya water intake was 57 which corresponds to moderately polluted.

Key words: Water quality, physico-chemical parameters, WQI, Asajaya water intake, moderately polluted.

ABSTRAK

Kajian ini dijalankan untuk menentukan kualiti air di lokasi punca sumber air Asajaya di Kota Samarahan berdasarkan parameter fizikal-kimia air. Lima belas parameter kualiti air telah diukur merangkumi suhu, pH, DO, kemasinan, kekeruhan, konduktiviti, TDS, ORP, nitrat, ammonia-N, ortofosfat, COD, klorofil-a, TSS dan BOD_5. Pengukuran paramater fizikal-kimia dijalankan dari bulan Ogos – Disember 08' dan Januari 09' di 3 lokasi yang berbeza. Analisis statistik ANOVA menunjukkan tiada perbezaan yang nyata dalam parameter kualiti air antara lokasi kecuali bagi data ortofosfat, BOD_5, TSS, DO, suhu dan nitrat. Sebaliknya, perbezaan yang nyata dalam parameter kualiti air ditunjukkan antara bulan. Purata parameter fizikal-kimia bagi kawasan persampelan adalah seperti berikut dengan suhu (25.68 ^{0}C), pH (5.01), DO (3.10 mg/L) , kemasinan (0.01 PSU), kekeruhan (66.24 NTU), konduktiviti (4.62 mS m^{-1}), TDS (0.04 g/L), ORP (231.04 mV), nitrat (0.02 mg/L), ammonia-N (2.00 mg/L), ortofosfat (0.48 mg/L), COD (72.84 mg/L), klorofil-a (1.23 μg/L), TSS (1.54 mg/L), dan BOD_5 (1.19 mg/L). Pengiraan WQI untuk kawasan punca sumber air Asajaya adalah 57 dan dikategorikan sebagai sederhana tercemar.

Kata kunci: Kualiti air, parameter fizikal-kimia, WQI, punca sumber air, Asajaya, sederhana tercemar.

1.0 Introduction

Our earth is unique in a way that it contains water. The earth is covered with 75% water. There is about 97.5% of saline water in the earth and left about 2.5% of non-saline water. However, not all freshwater is suitable for humans used. Less than 1% is for world's water supply. According to Gray (2005a), water is recycled through hydrological cycle and the total volume of water is constant. However, changes occur in term of quality and availability of the water. In addition, limnologists are worried of the quantity and quality of our freshwater (Horne & Goldman, 1994). Freshwater is important as drinking water and also for terrestrial organisms and agriculture activities. However, freshwater concentrations are lower and the volumes are smaller than saline water. Thus, freshwater ecosystem is highly exposed to pollutions (Gray, 2005a).

Water quality is express through its fitness used for various purposes. Different usage of water, need different requirements. Meybeck *et al.* (1996) stated that, there are two main factors of water quality and quantity disruption. The first factor is natural factor and the second is due to human activities. According to (Gray, 2005d), surface water is water bodies which are flowing or stagnant such as streams, rivers, ponds, lakes and reservoirs.

Gray (2005c) stated that, developments occur widely prior to the increase in populations and human activities have brought in pollutions into the environments. Thus, water quality assessment is very important to sustain and protect our surface and ground waters. Since the quality of water rarely remains static, continuous quality data are appropriate. This is because, quality of water changes with space, time, waste loads at different points and description of effluents.

Water treatment process is defined as a process of changing the properties of chemical, physical and biological content of the raw water into clean waters which are safe to be consumed and fulfill the standard stated by the Ministry of Health (MOH) (Appendix 3). There are three important factors in treated water systems which consist of water sources, water treatment plant and distributing system (Ibrahim, n.d). Water may be unsuitable for drinking as water rapidly absorbs both natural and anthropogenic substances. Therefore, the main objective of water treatment is to provide adequately clean and safe water supply. More specifically, water treatment must produce palatable, safe, clear, colourless and odourless, soft, non-corrosive and low organic content water supply (Gray, 2005e).

1.1 Problem Statement

Asajaya Water Treatment Plant serves as drinking water suppliers to almost 6,610 customers including Kampung Sadong Jaya, Kampung Sungai Buluh and some other villages. However, there is little detail information on water quality of the water intake. Thus, to improve the available information, this study was designed to assess the water quality and investigate the effects from developments towards the water intake.

1.2 Objectives

1.2.1 To assess the water quality of the water intake in Asajaya Treatment Plant based on physico-chemical parameters.

1.2.2 To determine the classification of the water intake by using WQI.

1.2.3 To relate the water quality of the water intake with its surrounding land use.

2.0 Literature review

2.1 Sources of water

Water for treatment is normally taken from surface water such as streams, rivers, dam, lake and sea. There are some criteria that must be considered before choosing water sources for supply purposes. Firstly, the water sources must be of high quality. This means, the water sources must be far from any point of pollutions. Besides that, the quantity of waters must also be high enough to be distributed to the consumer. If possible, to reduce any cost for building and operation, the water sources should be near to the treatment plant (Haron, 2005). Gray (2005d) emphasized that, catchment area around reservoirs should belong to the water supply company. The company will ensure that the catchment area is strictly control from farming practice and land use to maintain the quality of the water sources. However, reservoir is very expensive to construct. Furthermore, it might be less useful during drought seasons since the quantity to be supplied is limited.

2.2 Appearance of the water sources

According to Gray (2005d), the quality of water sources can be affected due to natural phenomena or due to human activities. As a result of geological factors, water quality can be affected. For example, the presence of fine particles from both organic and inorganic will affect the turbidity of the water with cloudy appearance. Chalk and limestone causes the appearance of clear hard water while impervious rocks cause the appearance of turbid soft waters. As for soft-water river, the river is turbid due to silt-washed from surface runoff. Meanwhile, lack of bed rock makes the water acidic. This river is normally drain peaty soils from the upland causing the appearance of clear brownyellow water, similar to beer colour (Appendix 1). This indicates that there is high concentration of humus material in the water.

2.3 Peat soils associate with nutrient

Peat layers which are rich in nutrient act as nutrient sources in surface water. Most of the input of nitrogen (N) and phosphorus (P) in the soil are from biogeochemical processes and uptake and lateral transport. A study of peat land areas in The Netherlands by Van and his colleagues (2007) showed that at shallow depth of peat layers, there was an increased in N and P sources until the depth about 6 m. Deeper than 6 m, N and P concentration decreases. At the end of the result, they concluded that the shallow depth layers contributed to N and P loading at the surface water. However, increase in water levels with 0.2 m may decreases the dissolved N by more than 30%. Meanwhile, increase of water level did not support clear desorption for P.

2.4 Factors affecting the quality of water sources

Natural phenomena such as geological, hydrological, topographical, meteorological and biological factors affect water quality. Four main types of natural processes in the water bodies are summarized in (Appendix 4). These four main types of processes are all dependant on the environmental factors. Firstly, erosion and weathering and increase in dissolved materials through evaporation are effects from climate and vegetation. Secondly, terrestrial vegetation will produce organic and nitrogenous substances due to decomposition of fallen leaves into the water. Lastly, aquatic vegetation such as algae and aquatic plants may affect nitrogenous, phosphorus and dissolved oxygen concentration and pH of water (Meybeck *et al.*, 1996).

Meybeck and his colleagues also find that human activities such as building of dams and flow diversion, pollutions such as domestic, industrial, urban and other wastewaters discharges, and chemicals from agricultural activities may lowered the quality of water. However, Gray (2005b) mentioned that diffuse pollution is the major problem which widely affects the water quality. Pollution of diffuse sources is the most problems which are difficult to control. The most common type of diffuse sources is land use activities. Some examples of these activities are agricultural, forestry and construction. These activities will bring down runoff into the water sources and affects the water quality. Meybeck *et al.* (1996) also states that diffuse sources can also result in eutrophication which not only occurs due to wastes discharges of high nutrients but also from livestock runoff and organic and inorganic fertilizers used for agriculture.

2.5 Significant of water quality with algae

Algae are free floating organisms which cannot be seen by naked eyes. However, when they occur in large number, the appearance of green colour will occur on the water surface (Horne & Goldman, 1994). Low water quality which contains high nutrient loading from wastewaters and agricultural activities are significant with the growing of algae in the water. Their growths are normally related to the occurrence of excess nitrogen and phosphorus in the water (Gray, 2005d). Moreover, Horne & Goldman (1994) also explained that silica is favourable by algae such as diatoms for their growth. However, waste discharges of silica are in minor state than nitrogen and phosphorus discharges. Apart from nutrients loads, other criteria to stimulate algae growth are enough light penetration and warm water. Large quantity of algae in the water sources may bring into unpleasant tastes even after treatment process. Falconer (1993) mentioned that in some cases, blue-green algae or cyanobacteria may also present in drinking water and some species may bear toxins in their cells. During treatment process, pre-chlorination will kill the algae cells. As the cells are killed, toxins will be released into the water. Thus, the water is unsafe to be supplied to the customer since the toxins cannot be removed by normal water filtration.

2.6 Parameters of water quality and water quality index (WQI)

Water quality focuses on the presence of foreign substances in the water and their effects to people or the aquatic environment. However, its quality cannot be simply judge as good or bad. Thus, quantitative data is important to determine and describe the condition of the water. Water quality parameters are things which can be measured to determine the quality of the water. Hence, three types of parameters which are physical, chemical and biological are very important especially for drinking water.

Water quality index is use to quantify the quality of water consisting of large amount of data into simple terms of either good or bad or polluted or unpolluted. This is important to be reported to the management as well as the public of the water quality status. Available indices used in a water quality index formula are mostly applicable only to lakes. Besides that, the numbers of variables used for water quality measurements is very simple. The common variables used for water quality index calculation are DO, BOD_5, COD, TSS, ammonia-N and pH. These parameters are normal indicators of water influence by domestic and industrial effluents (Nasirian, 2007).

According to Abdullah *et al.* (2008), lower than 5 mg/L of DO concentration, fish and other aquatic animals undergo stress. Meanwhile, lower than 2 mg/L will cause death to fish. The Department of Environment rating scales of DO level from 0 to 5 mg/L is adequate, 5 to 7 is acceptable and above 7 as highly acceptable.

Biological oxygen demand (BOD) is the amount of oxygen requires by microorganisms to decompose organic matter in the water. Abdullah and his colleagues stated that naturally occurring organic material such as plant decay can react with chlorine in water treatment plants forming harmful disinfectant by-products in drinking water. For example, as occurred in Semenyih, the BOD_5 is under acceptable level. Hence, it is very important to monitor disinfection by-products levels for safe drinking water to the communities.

Chemical oxygen demand (COD) is use to measure chemical waste in water and is correlated with BOD. In water, organic carbon will be oxidized to carbon dioxide by chemical oxidation. The DOE-INWQS COD rating levels are 1 to 10 mg/L as highly acceptable, 10 to 25 mg/L as acceptable and above 25 mg/L is adequate.

Total suspended solids (TSS) is to measure suspended material in the water. The DOE-INWQS TSS rating scales are 0 to 50 mg/L as highly acceptable, 50 to 100 as acceptable and 150 to > 300 as adequate.

Ammonia is a nitrogen source which is important for plants and algae. However, at higher temperature (32^0C) or higher pH (10), ammonium will be converted to ammonia. Ammonia gas can be harmful to the fish and aquatic life. The major causes of ammonia are from animal's excretion, production of plants and animals decomposition, certain industrial wastewaters and animal's feedlots runoff. Increase in pH and temperature make the ionized ammonia change to un-ionized ammonia in form of gas. If there is enough DO in the water, nitrifying bacteria will be easily broken down into nitrite and nitrate.

pH is used to describe the acidity or alkalinity of water. The DOE-INWQS rating scale for pH is highly acceptable between 6.5 and 8.4, acceptable for 6 and 9 and below 6.5 and above 9 as adequate.

3.0 Materials and methods

3.1 Study site

This study was conducted in Asajaya Water Treatment Plant, 1 kilometer from the roadside. Water samples were taken from the water intake site (Figure 1) which was 1.5 kilometer from the access road to Asajaya Water Treatment Plant. The coordinate of the water intake of Sungai Asajaya is N 01^{0} 30.980' E 110^{0} 36.302'.

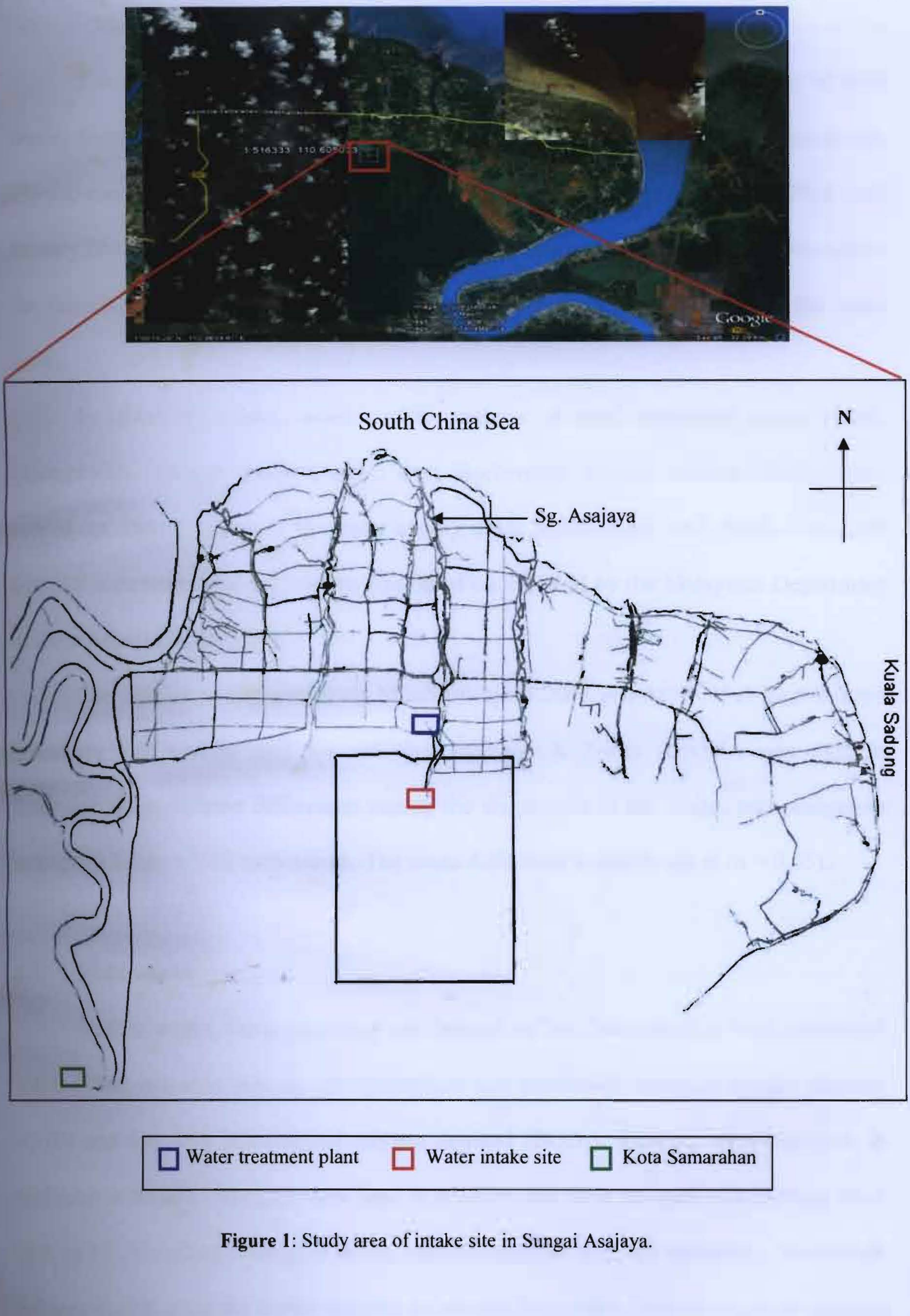

Figure 1: Study area of intake site in Sungai Asajaya.

3.2 Methodologies

This research was divided into two parts, field works and laboratory works. In field works, water sampling was carried out, followed by *in-situ* water quality measurements. Physico-chemical parameters were sampled monthly in the first week of August 2008 until January 2009. There were three replicates of samples taken at three sites. Site 1 was below the pump house, site 2 was near the river bank and site 3 was at the middle of the water intake.

In laboratory works, water quality analysis of total suspended solids (TSS), chlorophyll-*a*, nutrients analysis and 5 days biochemical oxygen demand (BOD_5) were carried out. Determination of the water quality index involves pH, DO, BOD, COD, AN and TSS parameters. The calculation was based on the WQI by the Malaysian Department of Environment (DOE, 2001).

The data was presented using Microsoft excel 2007 and SPSS 15.0 for windows evaluation version was used for statistical analysis. A 2-way ANOVA was used to determine the significant differences among the six months at the 3 sites and comparing among the 3 sites within each month. The mean difference is significant at ($\alpha = 0.05$).

3.3 Field works

In field works, water sampling was carried out for chlorophyll-*a*, total suspended solids (TSS), nutrients (nitrate, orthophosphate and ammonia), chemical oxygen demand (COD) and five days biochemical oxygen demand (BOD_5). Samples were collected in triplicates at the site. Samples were kept in a cooler box with ice packs for cooling from 25°C to 4°C. However, cooling of BOD_5 and TSS samples were not necessary. Aluminium foil was used to wrap the BOD_5 samples to prevent from light. Nutrient analysis samples need to be filtered before stored into freezer at - 20°C. The nutrients analysis was done as soon as possible or at least with 28 days of holding time. However, samples must be warmed in room temperature before analysis begins (Hach, 2000).

3.3.1 *In-situ* data collection

Coordinate of the location was measured using Global positioning system (GPS). *In-situ* parameters which were measured using HORIBA (W-2030) model were temperature, pH, dissolved oxygen (DO), salinity, turbidity, total dissolved solids (TDS), oxidation-reduction potential (ORP) and conductivity.

3.4 Laboratory works

Ex-situ data collection was carried out in the lab. These data include nitrate, ammonia-nitrogen, orthophosphate, chemical oxygen demand (COD), chlorophyll-*a,* total suspended solids and five days biochemical oxygen demand (BOD_5).

3.4.1 *Ex-situ* data collection

i. Nitrate

Standard method 8192, cadmium reduction method was used to determine the concentration of nitrate. Nitrate contain in the water was reduced into nitrite by cadmium metal. Pink-coloured was formed if there is nitrate present. This reaction occurs when nitrite ion in an acidic medium reacts with sulfanilic acid to form an intermediate diazonium salt which couples to chloromotrophic acid (Hach, 2000).

ii. Ammonia-nitrogen

Standard method 8038, Nessler method was used to determine the concentration of ammonia-nitrogen. The Polyvinyl Alcohol Dispersing Agent aids the colour formation in the reaction of Nessler Reagent with ammonium ions. A yellow colour was formed proportional to the ammonia concentrations (Hach, 2000).

iii. Orthophosphate

Standard Method 8048, Ascorbic Acid method was used to analyse orthophosphate in the water sample. A blue colour will form which determine the present of orthophosphate or reactive phosphorous. Reaction occurs as the molybdate form a phosphomolybdate complex, which then be reduced by ascorbic acid. (Hach, 2000).

iv. Chemical oxygen demand (COD)

Standard method 8000 (Reactor digestion method) was used to measure the chemical oxygen demand. The samples were heated for 2 hours with potassium dichromate using COD heat reactor. Oxidisable organic compound react, reducing the dichromate ion (CrO_7^{2}) to green chromic ion (Cr^{3+}) (Hach, 2000).

v. Chlorophyll-*a*

Chlorophyll-*a* test was based on the APHA (1998). Concentration of chlorophyll-*a* was measured through acetone extraction and spectrophotometry. 1 L of water sample was filtered depends on the turbidity of the water using a 0.45 µm membrane filter. The filtrate was then grind in 5 ml of 90 % aqueous acetone and transferred into a tube containing 10 mL of 90 % aqueous acetone. The test tube